MEMORY AND VISUAL SEARCH BEHAVIOUR IN SCHIZOPHRENIA

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by

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ABSTRACT

The response times of 10 paranoid, 10 nonparanoid and 20 normals were compared on a visual search task which required subjects to identify one of several memorized target letters embedded in displays of varying numbers of nontarget letters. The rate of increase in response times as a function of both memory and display loads was similar for all groups, suggesting that, in this type of task, processing operations and strategies in schizophrenics are no different to those in normals. Results are discussed with reference to the cognitive deficit theories of Yates and McGhie.

CONTENTS

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

This thesis reports an experiment which uses measures of response latency as a means of examining the ability of schizophrenics to process visually presented information. It bears directly on theories of cognitive deficit in schizophrenia (McGhie, 1970; Yates, 1966a, 1973) and grows out of a series of similar experiments by Knight (1975).

A brief review of relevant cognitive deficit literature is mow presented.

Babcock (1930, 1933) first investigated in detail the suggestion that schizophrenics are characterized by extreme slowness of functioning. She demonstrated, on a number of simple motor and mental speed tests, that psychotics gained significantly lower scores than normals. These basic findings have been replicated and extended many times since this early study (Buss and Lang, 1965; Lang and Buss, 1965; Silverman, 1964a; Yates, 1966a, 1973; Zimet and Fisherman, 1970). The interpretation of such findings remains, however, a matter of some dispute.

In recent years information processing accounts of schizophrenic deficits have been proposed by several theorists.

McGhie and his associates have concentrated on investigating the effects of distracting inputs on the processing of information. In a task where subjects were asked to recall letter or digit sequences, they found that both visual and auditory distraction differentially affected schizophrenics compared to controls (McGhie, Chapman and Lawson, 1965a), and that the distraction effect was confined largely to hebephrenic schizophrenics (Lawson, McGhie and Chapman, 1967).

The McGhie findings have generally been confirmed by other investigators (e.g. Payne and Caird, 1967) and have led to a theoretical interpretation of the data by McGhie and others in terms of Broadbent's (1958) model of selective attention.

McGhie (1970) suggests that in schizophrenia there is an impairment of the normal filtering mechanism of attention, as formulated by Broadbent (1958), by which limited information is taken in for processing. A breakdown in filtering leads to "overloading" of the short term memory system for both relevant and distracting stimuli, an overloading which causes a failure to select out and thus to respond to relevant stimuli. This appears particularly true of tasks involving complex or unpredictable stimuli.

Yates (1966a, 1966b, 1973) departs somewhat from the interference due to irrelevant stimulation, hypothesizing that the schizophrenic is unable to handle relevant information at the same rate as normals. Yates (1966a) points out that there are at least 4 points where breakdown may occur; (a) at the receptor level, where data is received,

(b) at the data processing level, (c) at the cortical or central processing level, including short term memory and long term memory store, or, (d) at the level of the motor response. In terms of Broadbent's model, the breakdown occurs in schizophrenics at the data processing level where information is not processed quickly enough to prevent the loss of other relevant information stored in the short term memory system. Hence only part of the relevant information is processed, which over long periods of time, results in thought disorder and other bizarre behaviour.

Reaction time (RT) studies which manipulate stimulus demands are of direct relevance to Yates' theory. In general it has been found, on a variety of differing tasks, that schizophrenics, particularly nonparanoid who have been hospitalized for long periods, have much longer RT's than controls. (Bellissimo and Steffy, 1972; Court and Garwoli, 1968; Huston, Shakow and Riggs, 1937; Karras, 1973; Korboot and Yates, 1973; Marshall, 1973; Royer and Friedman, 1973; Slade, 1971; Yates, 1973; Yates and Korboot, 1970).

Among the factors which Smith (1968) cites as being known to affect RT in normal subjects include stimulus uncertainty (or the number of different stimuli) and response uncertainty (or the number of response alternatives). Typically, a linear increasing relationship between RT and combined stimulus response uncertainty has been found in normal subjects (Smith, 1968).

Court (1967) Court and Garwoli (1968) and Karras (1967) have noted that to substantiate Yates' theory, the lines relating

RT to complexity should be nonparallel for schizophrenics and normals, i.e. the rate of increase in RT with increased uncertainty should be greater for schizophrenics. Research findings concerning this have not been straightforward. Karras (1967), employing a simple and two-choice RT task, found that the performance of chronic schizophrenics did not deteriorate in the more complex condition. Court (1967) suggested that his results did not constitute a valid refutation of Yates' theory, and Court and Garwoli (1968), using short-stay patients with an arrangement of lights and keys, found increasing complexity did not produce a disproportionately higher RT amongst schizophrenics. They concluded that these results similarly did not detract from Yates' formulation which does not predict a greater deficit among schizophrenics with greater complexity unless there is continuous pressure to respond. This interpretation is supported by the results of Slade (1971), using a continuous card sorting task (based on Crossman, 1953), who found that the more "bits" of information to be processed, the greater the performance deficit in schizophrenics.

Yates and Korboot (1970) and Korboot and Yates (1973) replicated a study by Harwood and Naylor (1963), using acute and chronic, paranoid and nonparanoid and neurotic subjects. Stimulus elements were either lines, symbols or 2-letter words presented in a tachistoscope device, and subjects were required to report how many stimulus elements (from one to five) were present on each trial. Results indicated that with increasing stimulus complexity, inspection time increased more rapidly for chronic nonparanoid schizophrenics than for other groups.

Norman (1968) has stressed the point that all input, both relevant and irrelevant, must be processed at least to some extent for its irrelevancy to be established. For this reason, selective attention to sections of a visual display is best considered from within the total framework of visual information processing, as Kahneman (1973) and Erdelyi (1974) point out. Yates and McGhie do not appear to realize this and consequently pay little attention to the perceptual processes involved in selection in the visual field.

Kahneman (1973) moved away from a structural model and its postulates of processing channels and structures (e.g. Broadbent, 1971; Triesman, 1969). His limited capacity model postulates instead the existence of a circumscribed "quantity" or pool of capacity, effort or attention. Such capacity is distributed by means of an allocation policy to a variety of simultaneously ongoing activities which compete for the available supply. When the demands of one activity require more capacity or attention, more effort is expended in that direction and less is available for other activities. Kahneman further argues that the total pool of capacity itself varies with total demands.

Knight (1975) suggests that the capacity theory might be extended to explain cognitive deficit not only in schizophrenia but also in other psychiatric disturbances, by introducing the basic premise that capacity is reduced by certain mental disorders. If this was so, a schizophrenic deficit, relative to controls, would be more likely on tasks which were more demanding of capacity for normals, and the deficit would become greater with increased total demand.

However, schizophrenics would not necessarily have slower response times under certain conditions.

Frith (1973), in reviewing studies purporting to investigate perceptual processes in schizophrenics, suggested that tasks requiring a person to search for certain elements in an array provide a convenient means for investigating such processes. Recently, several researchers have done just this.

Royer and Friedman (1973), using process and reactive schizophrenics and hospitalized and nonhospitalized normals, measured time to locate a target design in an array of four designs. Designs and arrays differed in size of the rotation and equivalence sets from which they were selected. Results indicated that while schizophrenic groups were slower than nonhospitalized normals, there was no significant group x stimulus condition interaction, suggesting that schizophrenic response times are not differentially affected by increasing stimulus complexity.

Russell and Page (1976) employed a visual search task which required groups of paranoid, nonparanoid and normal subjects to identify which of two possible targets were embedded in a display containing up to eight nontarget letters. Results were similar to those of Royer and Friedman (1973) in that there was no marked differential increment in response times of patients which increases in display size.

Neale and his coworkers have carried out a number of experiments on perceptual span in schizophrenics, using Estes' (1965) Paradigm which involves a forced choice brief exposure recognition task where subjects are required to report which of two target letters are present on a given trial. Neale, McIntyre, Fox and Cromwell (1969) reported a preliminary study, using acute good premorbid paranoids, acute poor premorbid nonparanoids, and hospital aides, in which the target letter was presented either alone or with seven "noise" letters. They found that schizophrenics, in the measure of probability correct, differed significantly from normals only at the eight letter level of complexity but not at the one letter level, while the two patient groups did not differ at either level.

Neale (1971) extended these results using either zero, three, seven or 11 "noise" letters. As in the previous study, schizophrenics did not differ from normals when only a single target was to be detected. However, when the target was presented in conjunction with varying numbers of irrelevant letters, the span of schizophrenics was significantly less than that of two control groups. In contrast to other subjects, the span of schizophrenics reached an upper limit at a small display size and showed no further increase.

Cash, Neale and Cromwell (1972) in a further study found that schizophrenics did not significantly differ from normals in their performance. However, response requirements were different from those in the earlier studies in that whole report procedures were used, i.e. subjects were required to report everything they saw.

Knight (1975) carried out several studies on scanning behaviour in schizophrenics. In the first task, paranoid, nonparanoid and normal subjects were required to scan through multielement arrays and to report whether all the letters were the same or whether one or more of the letters were different. The second task also involved a same/different decision but to stimuli that consisted of two groups of either words or nonwords. In both of these tasks there was no significant differences between patient groups, but the combined schizophrenic group obtained significantly slower response times compared to the normal group. All but one of the interactions involving the group factor failed to reach significance, leading Knight to conclude that both tasks showed that conjectures "....that stimulus complexity differentially affects schizophrenics, are not necessarily true, or at least of minimal importance in relation to the large constant difference in RT." (p.215). In a third task subjects were required to search for the target letter "X" embedded in one of 50 rows of letters, each row consisting of four letters. Results indicated that increases in RT with increases in quantity of information were constant for both schizophrenics and normals.

In his first experiment involving three tasks, Knight (1975) used chronic schizophrenics from both admission and long-stay wards. However, in his second experiment, in which subjects were required to locate the presence or absence of a target letter in displays of up to 60 letters, he used process patients who had been institutionalized for less than a year. Results of this study indicated that: (1) there were no between group differences in RT, and, (2) the rate of increase in RT with increasing stimulus load was similar for both normals and schizophrenics.

Knight's (1975) studies involving search for a target in visual displays were based on work with normals by Neisser and his colleagues. Neisser (1963) required subjects to search through rows of visually presented letters for the presence or absence of one or more memorized target items. He demonstrated that a linear regression line could be fitted to the data relating number of letters scanned to RT.

Neisser, Novick and Lazar (1963) extended this study in a task where subjects were required to search for up to 10 targets in a visual display. While they found that, with extensive practice, subjects could search for 10 items as quickly as for one, Kaplan and Carvellas (1965) and Kaplan, Carvellas and Metlay (1966) found that, in search for targets just specified, scanning time increased with the number of targets searched for.

It is evident that searching for a number of targets in the Neisser type paradigm involves components of memory search or processing as well as visual processing of items in a display. As such, in many respects, the task is similar to that used by several investigators (e.g. Nickerson, 1966; Briggs and Blaha, 1969; Burrows and Murdock, 1969) in an extension of Sternberg's (1966) basic memory search paradigm.

In his original experiment, Sternberg (1966) presented brief exposures of a memory set of up to six digits, and then a single "probe" or test stimulus. Subjects were required to report whether or not the probe was a member of the previously presented memory set. Results showed: (1) RT increased linearly with the number of items in the memory set, and, (2) the linearity held for both positive and negative probes, i.e., for both "yes" and "no" responses.

Nickerson (1966), in a series of experiments, extended the memory search paradigm to manipulate the number of display elements as well as the number in the memory set. Subjects were required to make a positive response if any of the first set of letters (checklist) were included in the second set (searchlist). Up to four letters were used in each set. Nickerson's finding that RT increased with increases in the size of either set has been replicated by Briggs and Blaha (1969) and Burrows and Murdock (1969).

The recent studies of Knight (1975), Royer and Friedman(1973) and Russell and Page (1976) suggest that in a visual search task where memory and response demands are minimized, increasing stimulus load alone has no differential effect on RT's of schizophrenics as compared to normals. Such results are not compatible with Yates' slow processing theory nor with McGhie's attentional deficit theory. If schizophrenics do not appear to experience difficulty in processing incoming stimuli, we might ask if they would in a task where a greater memory component was added.

Nickerson (1966) and others have shown that RT increases in normal subjects both with increased display and memory loads. Therefore it was proposed to conduct an experiment, along the lines of Nickerson, in which paranoid, nonparanoid and normal subjects were required to locate the presence or absence of a previously learned set of targets in visual displays of varying sizes.

CHAPTER TWO

THE EXPERIMENT

(1) Experimental Design

Subjects were required to search through circular displays of one, five or fifteen letters (display loads of $\underline{d} = 1$, $\underline{d} = 5$ and $\underline{d} = 15$) for a predesignated target which was present in half the displays. The task was to respond "yes" if the target was present, and "no" if the target was unable to be detected. In the first memory load condition ($\underline{m} = 1$), the target was always the letter "M", with the memory load of three ($\underline{m} = 3$), the target was selected from a memorized set of three possible targets, and in the memory load of six condition ($\underline{m} = 6$), the target was selected from a memorized set of six possible targets.

The experimental design involved four factors. These were: (a) group, and subjects were divided into three groups, as defined below, (b) memory load, involving three levels, i.e. 1, 3 or 6, (c) display load, involving three levels, i.e. 1, 5 or 15, and (d) target, in which target present and target absent were used with equal probability.

Selection of Target Letters

For the $\underline{m} = 3$ condition, the letters "W", "S" and "F"were selected from the pool of 21% association values listed in the Witmer norms of association for CCC trigrams (Underwood and Schulz, 1960, pp. 318-324). Letters were chosen from this pool because they formed no known New Zealand abbreviation and contained a combination of letters of straight line and curved features (Neisser, 1963).

For the $\underline{m}$ = 6 condition, two such trigrams were chosen according to the above criterion and so that no letter was repeated or shared a letter with the $\underline{m}$ = 3 set. Accordingly, the letters "D", "L", "Z", "G", "Q", and "N" were selected. For the $\underline{m}$ = 1 condition, the letter "M", which was not included in the above two sets, was chosen.

Low association CCC's were chosen in an attempt to equate the memorability of target sets for all three groups, previous research having shown that schizophrenic recall and recognition is more likely to equal that of normals when the to-be-remembered material is of low organization or structure (e.g. Russell, Bannatyne and Smith, 1975).

Stimuli

At each display load $\underline{d}$ = 1, $\underline{d}$ = 5 and $\underline{d}$ = 15, for each of the memory load conditions $\underline{m}$ = 1, $\underline{m}$ = 3 and $\underline{m}$ = 6, six target present and six target absent displays were generated to form a total of 108 displays (i.e. 6 x 2 x 3 x 3). For the $\underline{m}$ = 1 condition, six target present displays, each featuring the target "M" were formed, with $\underline{m}$ = 3 two target present displays were formed for each of the targets "W", "S" and "F" and in the $\underline{m}$ = 6 condition, only the one target present display was formed for each target "D", "L", "Z", "G", "Q" and "N". Thus, in each of the combinations of display load and memory load, half the displays contained a target and half did not (target absent), while in all conditions, the targets within a multi-target set appeared with equal frequency.

In the conditions $\underline{m} = 1$, $\underline{m} = 3$ and $\underline{m} = 6$, the nontarget letters were drawn respectively from the remaining 25, 23, and 20 letters of the alphabet. Thus, while memory or target sets contained no letters in common, target letters of one memory set featured as nontargets in another.

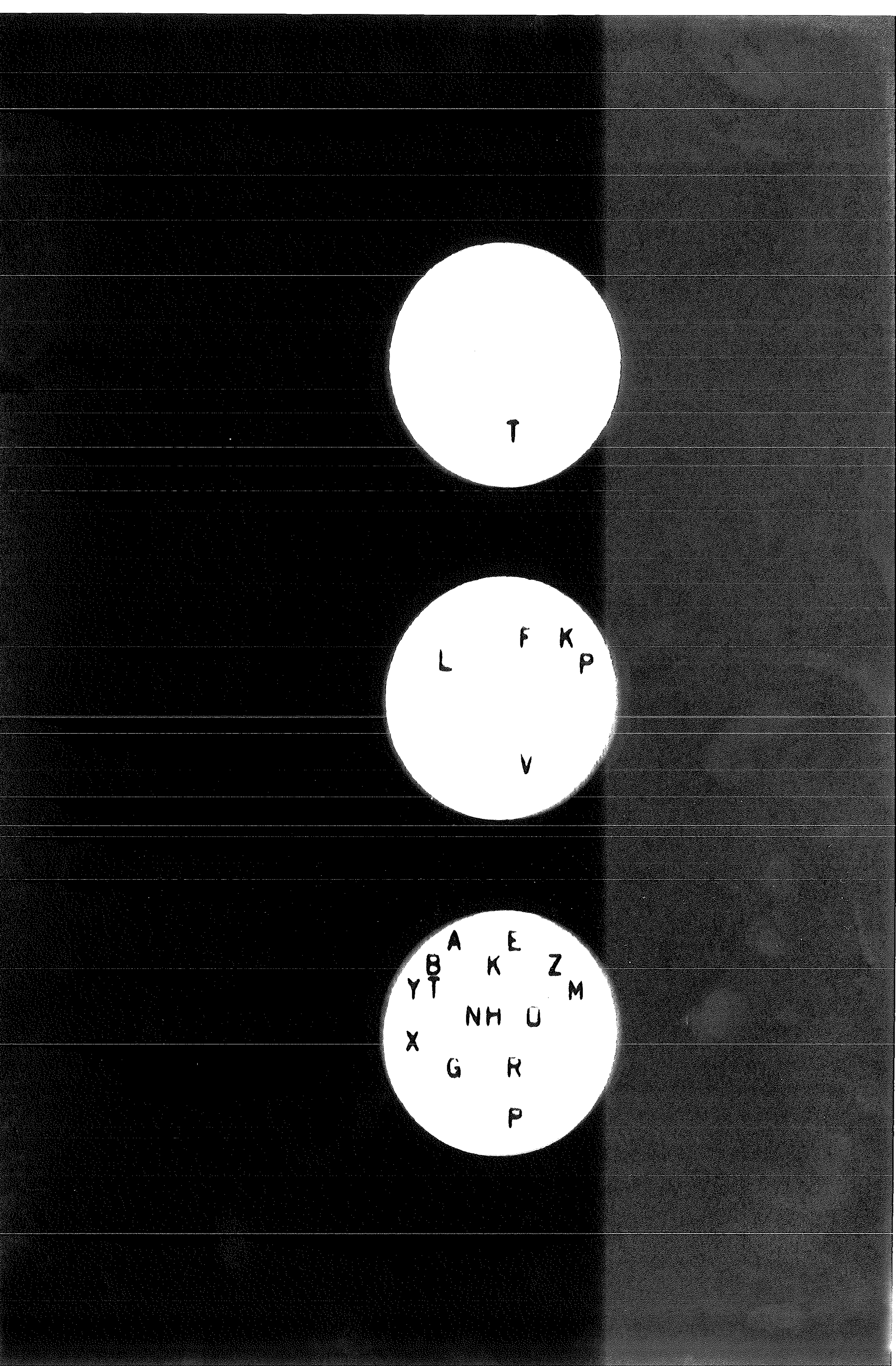
The nontarget letters for each display were selected at random without replacement from the appropriate nontarget letter pool by a suitably programmed Burroughs B6718 computer. The same computer program arranged the print out of each display so that both the target (if present) and nontarget letters were randomly positioned within the confines of a circular area of diameter 2.54 cm with no two letters occupying the same position and with letter separations being multiples of the printer's normal horizontal and vertical spacings. The displays (black print on white) were centred in a 3.2 cm circular hole cut in a large sheet of cardboard, and slide mounts were prepared so that when projected, the white circular area was completely surrounded by a dark grey area. (See Figure 1 for stimuli samples). Subjects sat with their eyes approximately 165 cm from the projected circular display of diameter 19.5 cms (visual angle $6^{\circ} 44'$) and viewed the projected upper case letters which measured 1.8 cms in height (visual angle $0^{\circ} 38'$) and 1.2 cms in width (visual angle $0^{\circ} 25'$).

All subjects received the $\underline{m} = 1$ block of displays, followed by the $\underline{m} = 3$ and $\underline{m} = 6$ blocks of displays. Within blocks, displays from the various display loads and target present/

Figure 1

Samples of stimuli from

displays of 1, 5 and 15 letters


T
F K L P V
A E B K Z Y T M N H U X G R P

target absent conditions were presented in random order, the same ordering being used for all subjects.

In terms of comparison with the character recognition experiments of Sternberg (1966), it needs to be noted that the present experiment differed from the usual Sternberg fixed set procedure in that the "probe" item was randomly positioned within a circular display area and not of constant location. Further, the single display trials occurred in the context of multiletter displays.

(2) Apparatus

A Kodak Carousel projector model SAV-2000 was used to present slides. A Lafayette electrically operated shutter (Model 43011) on the projector was connected to a finger key which, when pressed down by the subject, initiated, after a 0.5 sec. delay (controlled by a Lafayette Interval Timer, Model 50011), the projection of a slide and simultaneously started a Lafayette clock/counter (Model 54517). Both the slide display and the clock stayed on until the subject made a response into a microphone, connected to a Lafayette voice-activated relay (Model 604 A). The response terminated both the slide display and the clock. While the sensitivity of the voice-activated relay could be adjusted to compensate for subject variations, in practice it was unnecessary to do this.

(3) Selection of Subjects

Schizophrenic Subjects

The Sample tested was drawn from four admission wards and one long stay ward at Sunnyside Hospital, Christchurch, New Zealand, during August, September and October, 1975. It was decided to select the sample on the basis of psychiatrists' diagnoses, case histories and psychologists' observations of patients.

Clinical subjects were classified into two groups: paranoid and nonparanoid. This was done for two reasons. Firstly, paranoid and nonparanoid schizophrenics are often treated as distinct groups (Lang and Buss, 1965; Schooler and Feldman, 1967; Ullman and Krasner, 1969) and paranoids have been frequently noted to perform differently from nonparanoids (Chapman and McGhie, 1962; Lawson, McGhie and Chapman, 1967; Payne, 1973; Russell and Page, 1976; Silverman, 1964b; Slade, 1971). Secondly, Johannsen, Friedman, Leitschuh and Ammons (1963) imply that the paranoid/nonparanoid dichotomy may be the most relevant to apply to schizophrenics in that it cuts across the acute-chronic, poor premorbid/good premorbid and process-reactive typologies. Paranoid status was determined by a consensus of two psychiatrists and two psychologists, previous researchers (e.g. Beekhuis, 1974) having incidentally found that paranoid/nonparanoid classifications under Gordon and Gregson's (1970) modification of the Sympton Sign Inventory bear little relation to hospital diagnoses.

The psychiatrists responsible for each of the five wards sampled were asked to compile a list of process schizophrenics. Schizophrenic diagnoses were confirmed using the criteria laid down in the New Haven Schizophrenia Index, developed by Astrachan, Harrow, Adler, Bauer, Schwartz, Schwartz and

Tucker (1972) while the Phillips (1953) Premorbid Scale confirmed the process dimension.

To avoid the possibility of confounding due to length of institutionalization (Strauss, 1973), only those whose current period of hospitalization was less than six months were considered to be suitable clinical subjects. Patients with a gross motor disability or whose schizophrenic symptons were the products of, or complicated by, organic etiology, were excluded from the sample. Only patients who were aged between 19 and 60 years, were not receiving electro-convulsive therapy, and who had no secondary diagnosis (e.g. alcoholism, epilepsy, mental retardation) were used in the study. Further, patients who were currently in an acute phase of their illness, who were diagnosed schizo-affective or who were clearly reactive schizophrenics were eliminated from the study.

Of the subjects finally selected for testing, three were subsequently eliminated because they were too acutely disturbed to perform the task, while one subject refused to take part in the experiment. All subjects were tested for visual acuity by requiring them to read letters presented to them in a manner similar to that used in the experimental task. It was found that two of the subjects were unable to do this adequately, one of which was due to myopia and the other to blurring of vision as a medication side-effect. These two subjects did not participate in the subsequent experimental task.

Subject variables	Paranoid	Nonparanoid	Normal
Age			
Mean	39.2	30.0	34.1
S.D.	10.8	10.8	12.2
WAIS Vocabulary			
Mean	11.8	10.7	11.25
S.D.	2.4	3.3	2.67

Table 1. Group means and standard deviations of selected subject variables

Control Group Subjects

A group of nonpsychiatric, noninstitutionalized control subjects were drawn from the general population and chosen to match the schizophrenic subjects for sex, age, IQ and occupational status.

Details of selected subject variables are presented in Table 1.

(4) Procedure

Subjects were tested in the Psychology Department of Sunnyside Hospital. An overhead fluorescent tube was kept alight at all times in an effort to standardize lighting conditions as much as possible. Subjects sat behind a desk, facing the wall onto which slides were projected.

They were told:

> "We are interested in finding out how quickly people can see things, and I am testing a wide variety of people to try and find out about this. I will be asking you to try and remember either one or several different letters. When you think you have this letter or letters firmly fixed in your mind, I will be showing you some slides with a number of letters on them.
> Your task will be to tell me as quickly as possible whether or not any of the letters you have memorized are present."

Subjects were asked to read aloud the letters displayed on one of the practice slides containing five display letters.

Those who were unable to do this easily and without making errors were eliminated from the experiment. Twelve practice trials were then given. Instructions were similar to the first part of the standardized instructions (see below) but substituting the letter "X" for the letter "M". The apparatus was explained to the subjects and any questions were answered as fully as possible. Those who were unable to complete the practice trials did not continue with the experimental trials.

The standardized instructions for the first part of the experiment were then read to the subject:

> "There are three parts to this study. In the first part you have only one letter to remember - the letter 'M'. After I say the word 'ready' you may press the key in front of you. A slide showing a number of letters will then appear on the wall in front of you. If there is an 'M' present, say 'yes' into the microphone as quickly as you can; if there is not, say 'no'. Do not say anything else until you are ready to tell me whether or not the 'M' is there."

All subjects received the first block of trials, i.e. the $\underline{m} = 1$ set. The intertrial interval was determined by the subject who had complete control over the apparatus once the new stimulus had been placed in position in the projector.

At the completion of the first block of trials, subjects were given a short rest period if it was desired. Further instructions concerning the second block of trials, i.e. the $\underline{m} = 3$ set, were then read.

> "Now we come to the second part, and you will not be required to remember the letter 'M' any more. This time I want you to remember three letters, 'W', 'S' and 'F'. If <u>any</u> of these letters is present amongst the letters on the slide say 'yes' as quickly as you can; if <u>none</u> of them is present, say 'no'. Give yourself plenty of time to memorize the three letters as it is important that you do not forget them."

Subjects were given as long as was necessary for them to memorize the letters, and before the trials began, were required to repeat these without error. They were urged, if at any stage throughout the trials, they were unable to remember the target set, to ask the experimenter to recall aloud the letters to them during an intertrial interval, and not after they had initiated the next slide.

For the $\underline{m} = 6$ block subjects were told:

> "In the last part you have six letters to remember - 'D', 'L', 'Z', 'G', 'N', and 'Q'. The same rules as last time apply again. If <u>any</u> of these letters is present, etc. etc."

Further efforts made to ensure that the target letters were retained in memory included asking subjects to repeat the six letters aloud on approximately every fifth trial.

Experimental sessions lasted from between 30 and 50 minutes, and were followed by the administration to all subjects of Jastak and Jastak's (1964) shortened form of the WAIS vocabulary subtest.

Display load	Paranoid		Nonparanoid		Normal	
	Misses	False alarms	Misses	False alarms	Misses	False alarms
			Memory load = 1			
1	0.000	0.000	0.017	0.000	0.000	0.008
5	0.000	0.017	0.033	0.000	0.017	0.008
15	0.083	0.017	0.117	0.033	0.058	0.008
			Memory load = 3			
1	0.000	0.000	0.050	0.000	0.000	0.000
5	0.100	0.000	0.083	0.000	0.008	0.000
15	0.250	0.033	0.317	0.033	0.033	0.017
			Memory load = 6			
1	0.017	0.000	0.033	0.017	0.008	0.008
5	0.150	0.033	0.183	0.100	0.150	0.025
15	0.500	0.050	0.417	0.083	0.383	0.008

Table 2. Probability of Error.

CHAPTER THREE

RESULTS

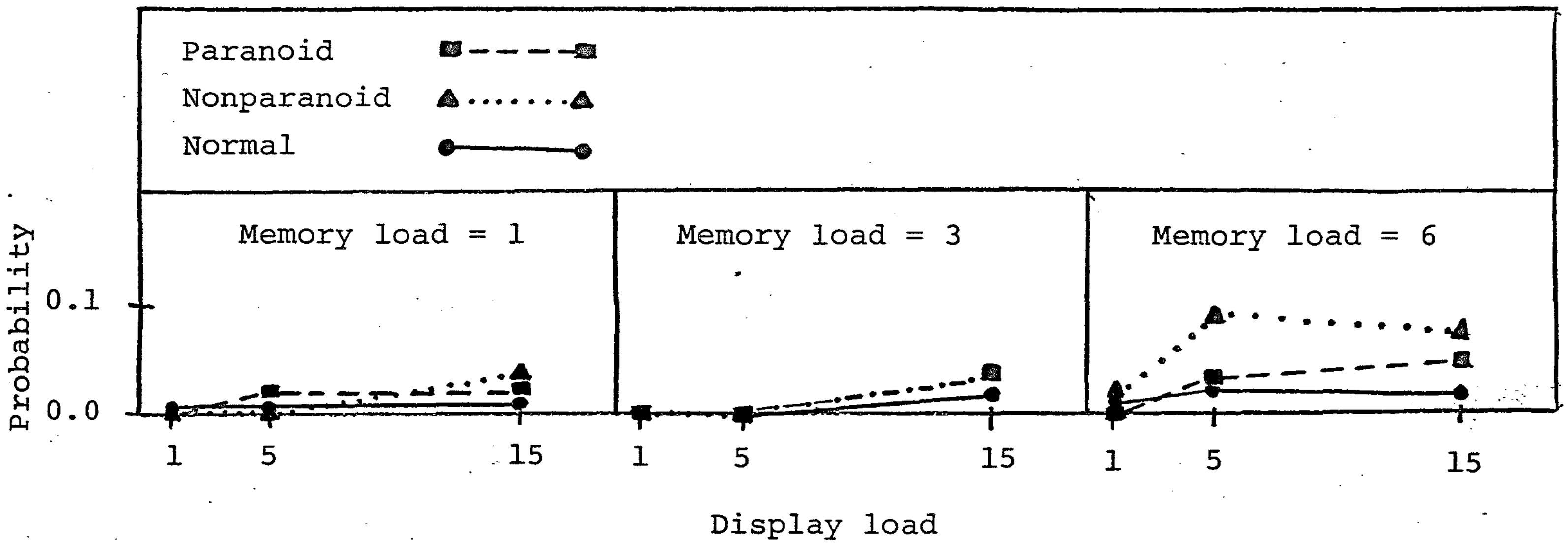
(1) Error Rates

Errors were subjected to analysis because the analysis of response times assumes an absence of errors, or at least a very low error rate. Two types of error were possible in the visual/memory search task reported here: (1) False alarms, which occurred when subjects erroneously perceived the presence of a target in target absent conditions, i.e. made a "Yes" response, and, (2) Misses, which occurred when subjects failed to perceive the presence of a target in target present conditions, i.e. made a "No" response.

The probability of error, that is, the number of errors summed across subjects and divided by the total number of trials in each condition, is presented in Table 2. Error data is also presented in Graphs 1 and 2.

False Alarms

Graph 1 indicates that false alarms were rare for all groups. In view of the relative infrequency of this type of error, statistical analysis was difficult. However, it was possible to compare groups in terms of the number of subjects in each group making one or more false alarms and the number making no errors. This was done for each memory load (m) condition and across all conditions by means of Fisher Exact probability tests. Accordingly, relevant figures for false alarms in each group are presented in Table 3.



Graph 1. Probability of errors - False alarms

Group	$\underline{m} = 1$	$\underline{m} = 3$	$\underline{m} = 6$	All
Paranoid	2	2	2	4
Nonparanoid	2	2	5	7
Combined schizophrenic	4	4	7	11
Normal	3	2	4	7

Table 3. Number of subjects in Each Group making One or More False Alarms in each Memory Load condition and across All conditions.

In both m = 1 and m = 3, the numbers of paranoid and nonparanoid subjects making false alarms were similar, so patient groups were combined in a comparison with normals. In neither condition was a significant difference between the combined schizophrenic group and normals found. While the number of nonparanoid subjects making false alarms in m = 6 was greater than in the paranoid group, this difference was not significant, and again patient groups were combined in a comparison with normals. As with the two previous conditions, in m = 6 the difference between the combined schizophrenic group and the normal group did not reach significance. Further collapsing the data over display load (d) as well as memory load conditions did not produce any significant differences. Thus, although in all cases the tendency was for patients to make more false alarms, nowhere does this tendency reach significance.

Graph 1 also shows that false alarms were inclined to increase with both memory and display load. In order to explore this further, the numbers of subjects who made more or less false alarms in m = 6 than in m = 1 and d = 15 than in d = 1 were found. This data is presented in Table 4 which shows that, using a Sign Test, only when all groups were combined were there significantly more false alarms made in m = 6 as compared to m = 1. It can be noted, however, that of 40 subjects, only 10 made more false alarms when memory load was higher. In general, then, false alarms were rare, similar for all groups, and relatively independent of memory or display loads.

Groups	memory conditions			display conditions		
	more	less	*p*	more	less	*p*
Paranoid	2	1	-	4	1	-
Nonparanoid	5	1	-	4	1	-
Normal	3	0	-	2	1	-
All groups	10	2	.05	10	3	-

<u>Table 4.</u> <u>Number of subjects making more or less false alarms in higher than in lower memory and display conditions</u>.

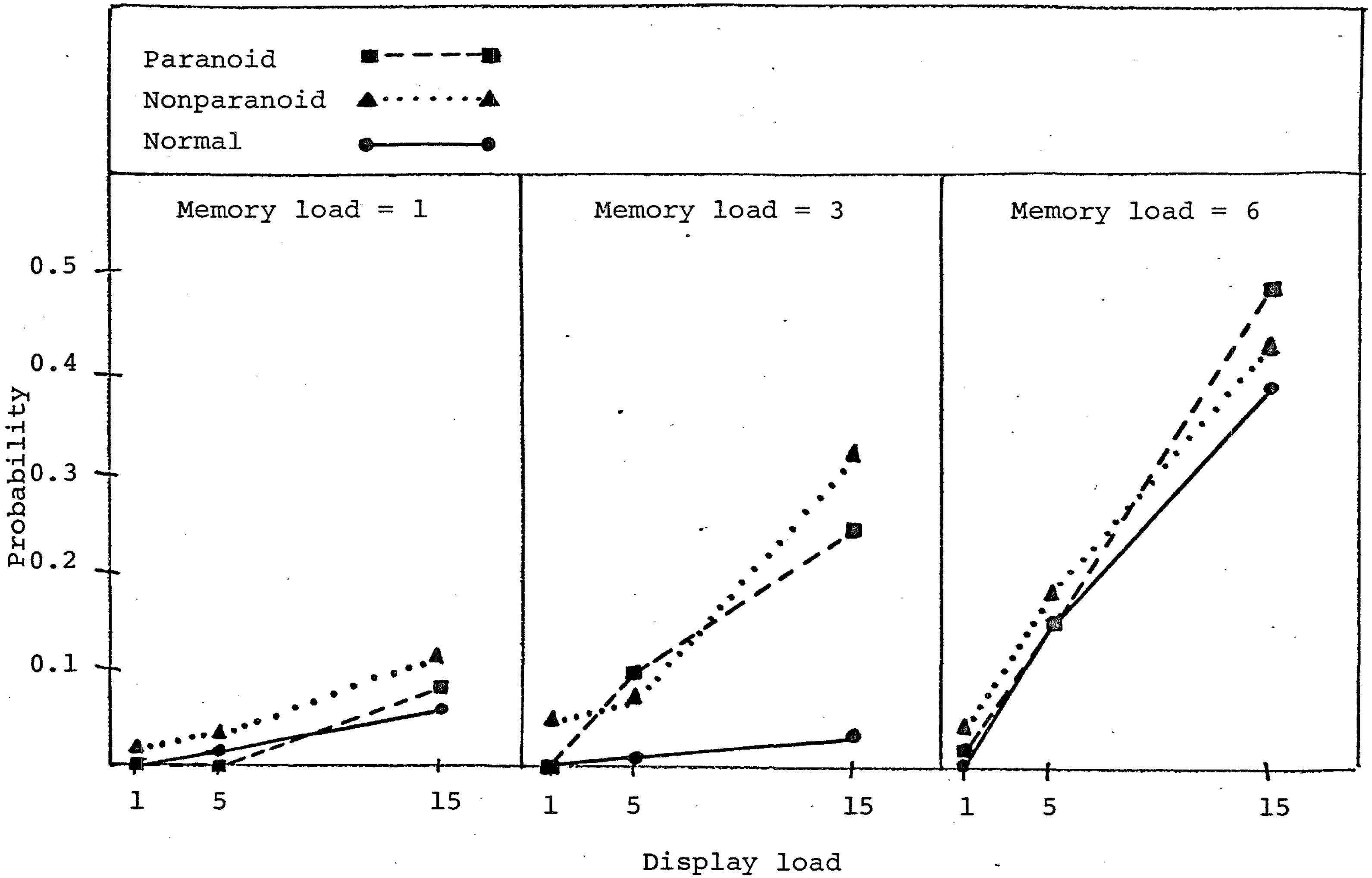
Misses

The probability or the frequency of misses has been shown in Table 2. Graph 2 indicates that misses were frequent and increased with memory and display loads, reaching almost 50 percent in the $\underline{m} = 6$, $\underline{d} = 15$ condition.

Possible group differences in the number of misses across all conditions were explored by an analysis of variance performed on the total number of misses per subject. A summary table is presented in Table 5 where it can be seen by the small F-ratio that groups did not differ in the number of misses.

In order to determine the effect of increasing memory and display loads, misses under $\underline{m} = 1$ and $\underline{d} = 1$ respectively were compared with those made under the higher $\underline{m} = 6$ and $\underline{d} = 15$ conditions. The means and standard deviations of the number of misses for each groups in these conditions are shown in Table 6. All 40 subjects made more misses when display load was greater, and the tendency for this to occur was significant by a Sign Test for all groups at $\underline{p} < .01$. All 10 paranoids, 8 of 10 nonparanoids and 19 of 20 normals made more misses when memory load was greater. Related measures t-tests performed on each group gave the following t-values: paranoid $\underline{t} = 7.00$, 9 df, $p < .001$; nonparanoid $\underline{t} = 3.33$, 9 df, $p < .01$; normal $\underline{t} = 9.85$, 19 df, $p < .001$. Thus, all groups made significantly more misses when memory and display loads were greater.

To determine whether groups differed in the rate of increase



Graph 2. Probability of errors - Misses

Table 5. ANOVA Summary Table:
Total number of misses per subject.

Source	*SS*	*df*	*MS*	*F*
Between groups	15.03	2	7.51	1.83
Within groups	151.75	37	4.10	
Total	166.77	39		

Table 6. Means and standard deviation of the number of misses per group.

Groups	Display load		Memory load		Total
	d = 1	*d* = 15	*m* = 1	*m* = 6	
Paranoid					
Mean	0.1	5.0	0.5	4.0	6.6
S.D.	-	1.18	-	1.34	1.69
Nonparanoid					
Mean	0.6	5.1	1.0	3.8	7.20
S.D.	-	2.02	-	1.33	2.31
Normal					
Mean	0.0	4.7	0.5	3.30	5.85
S.D.	-	1.71	-	1.18	1.87

Table 7. ANOVA Summary Table:

Increase in misses with memory load.

Source	SS	df	MS	F
Between groups	3.35	2	1.68	0.45
Within groups	136.65	37	3.69	
Total	140.00	39		

Table 8. ANOVA Summary Table:

Increase in misses with display load.

Source	SS	df	MS	F
Between groups	0.82	2	0.41	0.11
Within groups	137.95	37	3.73	
Total	138.77	39		

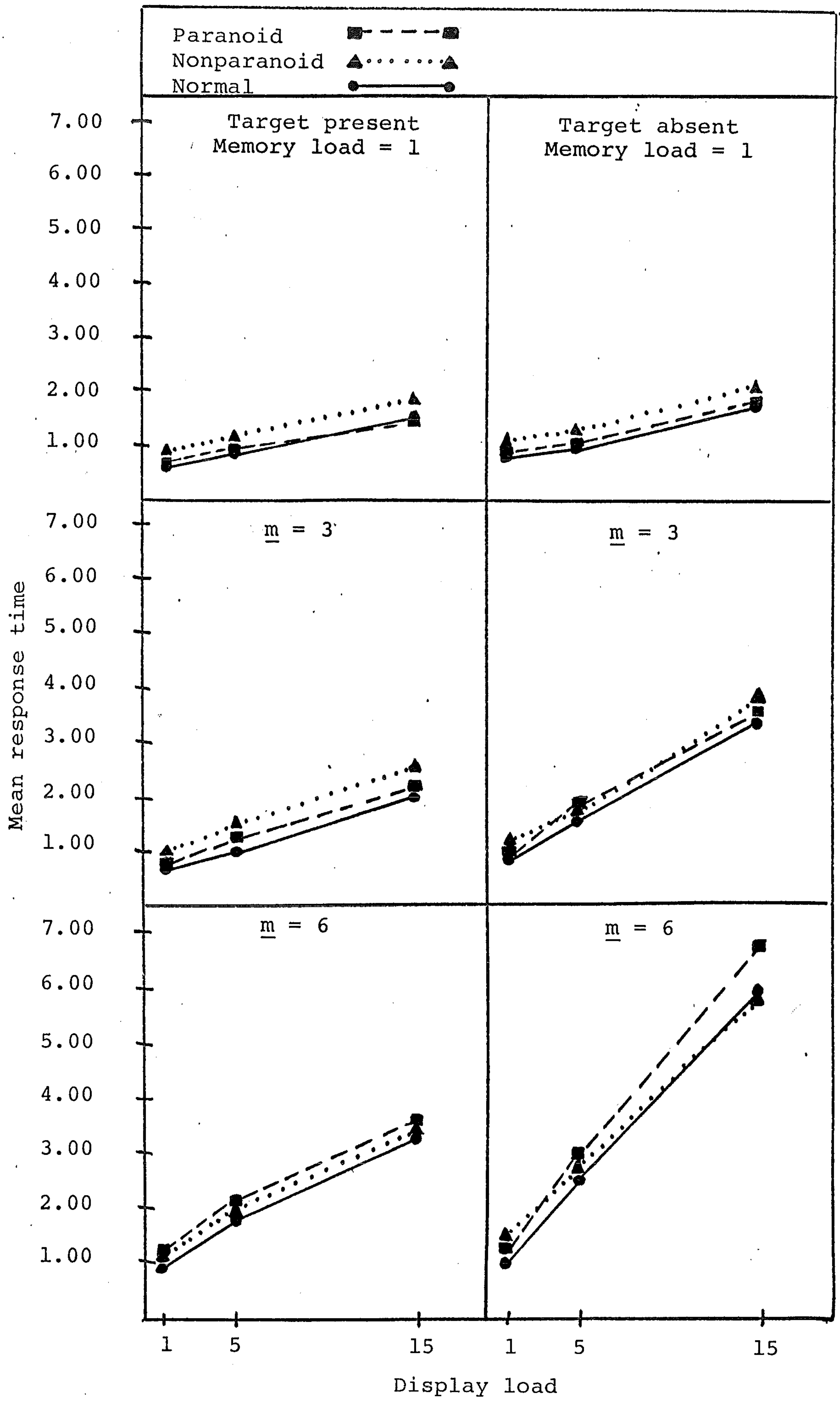
in misses with increases in memory and display loads, the increase in the number of misses between $\underline{m} = 1$ and $\underline{m} = 6$, and $\underline{d} = 1$ and $\underline{d} = 15$ was found for each subject and these scores were treated by separate between groups analyses of variance. The relevant summary tables are presented in Tables 7 and 8 and indicate no differences between groups in the rate of increase in misses with either memory or display loads.

(2) Response Times

The median response time of the correct responses to the six stimuli in each condition was calculated for each subject, and these formed the raw data of subsequent analyses. Medians were used in preference to means to reduce the effects of extreme noncharacteristic responses.

Table 9 presents the means and standard deviations of correct target present, correct target absent and miss response times for those subjects making misses in $\underline{m} = 3$ and $\underline{m} = 6$, $\underline{d} = 15$ conditions. Table 9 also gives probability levels for a series of related measures $\underline{t}$-tests, indicating that for all groups in these conditions, miss response times were significantly larger than the corresponding correct target present times but in no case did they differ significantly from correct target absent times.

The means and standard deviations for correct target present and correct target absent response times for all conditions are shown in Tables 10 and 11 respectively. These are also presented in Graph 3. Correct times were treated by a groups



Graph 3. Response time as a function of memory and display loads and target condition.

Table 9. Means and standard deviations of target missed, correct target present, and target absent response times for those subjects missing one or more targets in the display load of 15 condition.

	m = 3			m = 6		
	present	miss	absent	present	miss	absent
Paranoid						
Mean	2.33	3.68	3.84	3.57	6.87	6.75
S.D.	1.313	1.476	1.225	1.616	3.327	3.308
df	8		8	9		9
t	4.11**		0.62	3.20*		-0.13
Nonparanoid						
Mean	2.84	4.01	4.11	3.57	5.24	5.81
S.D.	1.634	1.817	1.666	1.025	1.843	2.263
df	8		8	9		9
t	3.73**		0.35	3.53**		1.20
Normal						
Mean	2.20	3.50	3.61	3.30	5.71	5.97
S.D.	0.904	1.255	1.613	1.385	2.409	2.332
df	18		18	19		19
t	5.03**		0.515	5.16**		1.106

* $p < .05$

** $p < .01$

Groups	m = 1			m = 3			m = 6		
	d = 1	d = 5	d = 15	d = 1	d = 5	d = 15	d = 1	d = 5	d = 15
Paranoid									
Mean	0.73	0.93	1.42	0.86	1.34	2.23	1.23	2.08	3.58
S.D.	0.055	0.215	0.437	0.179	0.418	1.281	0.292	0.670	1.616
Nonparanoid									
Mean	0.84	1.02	1.81	1.00	1.50	2.73	1.15	1.96	3.57
S.D.	0.219	0.246	0.597	0.204	0.847	1.583	0.203	0.673	1.025
Normal									
Mean	0.63	0.82	1.46	0.73	0.99	2.17	0.90	1.80	3.30
S.D.	0.064	0.089	0.409	0.078	0.180	0.888	0.138	0.412	1.385

Table 10. Means and standard deviations of correct target present response times for the various memory and display load conditions.

Groups	$m = 1$			$m = 3$			$m = 6$		
	$d = 1$	$d = 5$	$d = 15$	$d = 1$	$d = 5$	$d = 15$	$d = 1$	$d = 5$	$d = 15$
Paranoid									
Mean	0.85	0.99	1.84	0.93	1.83	3.63	1.22	2.94	6.75
S.D.	0.188	0.201	0.571	0.144	0.496	1.330	0.539	1.038	3.308
Nonparanoid									
Mean	0.93	1.15	1.97	1.02	1.72	3.92	1.36	2.65	5.81
S.D.	0.208	0.361	0.743	0.173	0.492	1.685	0.639	0.920	2.263
Normal									
Mean	0.71	0.88	1.72	0.79	1.53	3.54	0.96	2.49	5.98
S.D.	0.132	0.112	0.514	0.136	0.377	1.604	0.132	0.764	2.332

Table 11. Means and standard deviations of correct target absent response times in the various memory and display load conditions.

x memory load x display load x target present/target absent analysis of variance with repeated measures on memory, display and target factors. A summary of the results of this analysis is presented in Table 12.

The highly significant memory load, display load and target main effects confirm the trend, evident in Graph 3, for response times to increase with memory and display loads, and for target absent responses to be slower than target present responses. Graph 3 also indicates that the rate of increase in response time was greater with larger memory load, was greater for target absent than target present, and for the difference in the rate of increase between target present and target absent to increase with memory load. These trends are all strongly significant, with the memory x display (MD), display x target (DT) and memory x display x target (MDT) interactions all being significant beyond the .01 level. The significant memory x target (MT) interaction indicates that the tendency for target absent response times to exceed target present response times increases with memory load.

The display x target interaction was tested separately at each memory load condition, and was found to be significant beyond the .01 level at all conditions. The resultant _F_-ratios, with 2, 74 _df_, were 11.19, 35.55 and 54.23 for memory loads of 1, 3 and 6 respectively. Thus, for all memory load conditions, the rate of increase in response time with display load was greater for target absent than for target present.

Table 12. ANOVA Summary Table: Correct response times.

Source	SS	df	MS	F
Between Ss	184.3	39		
Group (G)	10.7	2	5.35	1.14
Ss within	173.6	37	4.69	
Within Ss	1741.4	680		
Memory load (M)	307.9	2	153.96	141.64 **
GM	3.4	4	0.85	0.79
M x Ss within	80.4	74	1.08	
Display Load (D)	644.5	2	322.28	190.51 **
GD	0.1	4	0.04	0.03
D x Ss within	125.1	74	1.69	
Target condition (T)	74.2	1	74.25	92.21 **
GT	0.7	2	0.36	0.46
T x Ss within	29.7	37	0.80	
MD	158.7	4	39.68	64.37 **
GMD	2.2	8	0.28	0.45
MD x Ss within	91.2	148	0.61	
MT	31.1	2	15.59	41.48 **
GMT	0.3	4	0.09	0.25
MT x Ss within	27.8	74	0.37	
DT	59.6	2	29.82	72.78 **
GDT	1.0	4	0.25	0.63
DT x Ss within	30.3	74	0.40	
MDT	31.8	4	7.95	29.84 **
GMDT	0.9	8	0.12	0.46
MDT x Ss within	39.4	148	0.26	
Total:	1925.7	719		

** $p < .01$

Groups	Memory load = 1		memory load = 3		memory load = 6	
	target present	target absent	target present	target absent	target present	target absent
Paranoid						
Slope	0.049	0.073	0.092	0.190	0.164	0.392
Constant	0.683	0.712	0.801	0.796	2.142	0.889
% variance	99.9	97.6	99.4	99.7	99.3	99.9
F	58.6	74.72	21.1	87.1	35.0	52.1
Nonparanoid						
Slope	0.071	0.076	0.124	0.209	0.170	0.317
Constant	0.730	0.820	0.877	0.756	1.033	1.053
% variance	98.9	99.3	99.9	99.8	99.7	99.9
F	60.2	61.8	17.2	62.8	74.8	91.0
Normal						
Slope	0.061	0.074	0.106	0.197	0.167	0.356
Constant	0.544	0.581	0.555	0.575	0.830	0.642
% variance	99.6	98.4	98.7	99.9	99.0	99.9
F	139.0	149.8	80.1	115.9	84.0	170.2

Note: For paranoid and nonparanoid *F* ratios use 1, 19 *df*; for normals use 1, 39

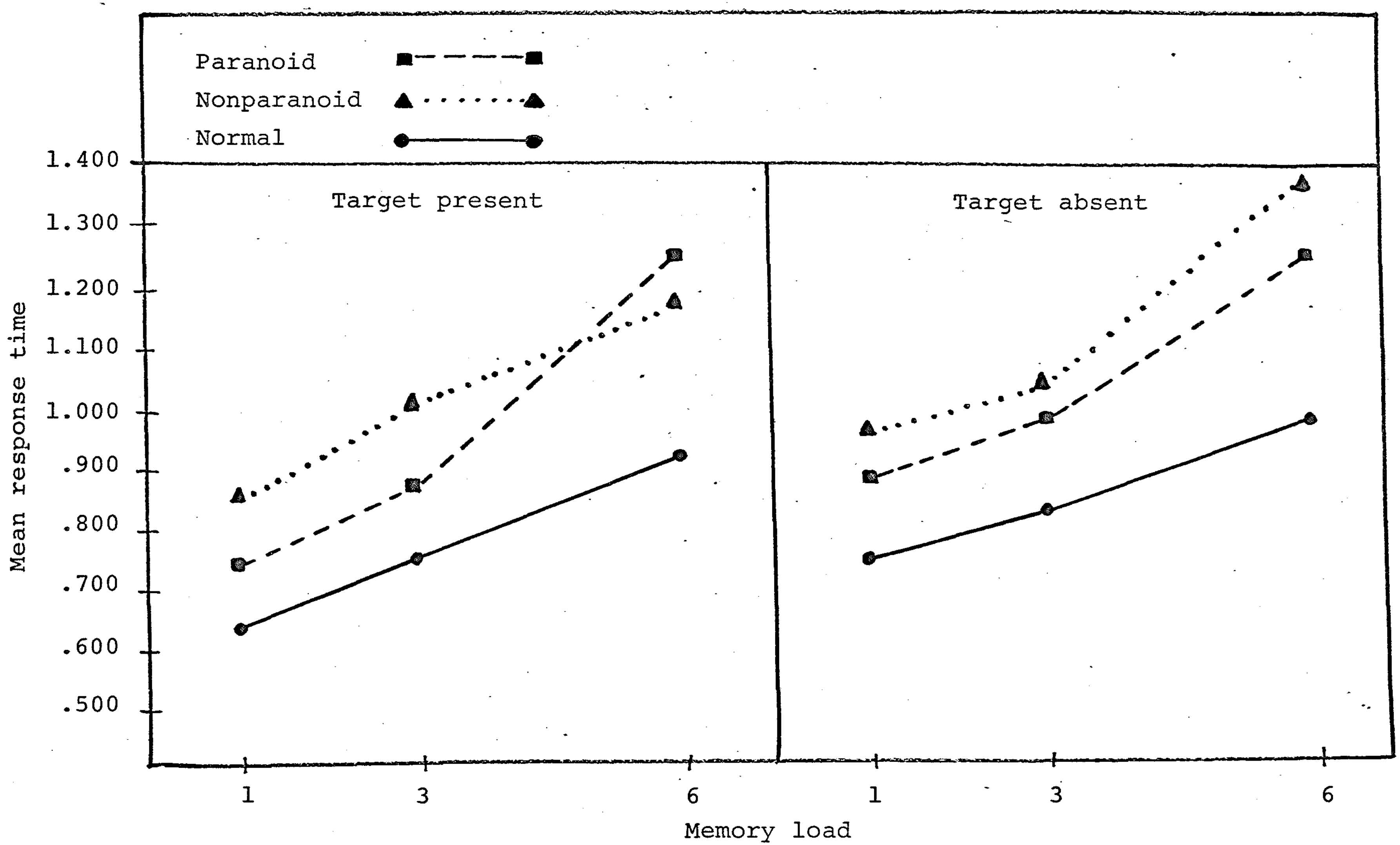
Table 13. Result of linear trend analyses expressing response time as a function of display load.

In contrast to the strong effects outlined above, no F-ratio involving the group factor approached significance. While schizophrenic, and particularly nonparanoid response times, were characteristically longer than those of normals, the group main effect failed to reach significance. Further, no two, three or four way interaction involving groups was significant, suggesting that schizophrenic response times increase with display and memory loads and target conditions in a manner similar to those of normals.

The groups x display interaction was tested separately for each memory/target combination, but in no case did the resultant F-ratio approach significance (largest $F = 1.12$; 2, 74 df). Thus, in no memory load/target condition combination did patients and normals differ in their rates of increase in response time with display load.

To describe the relationships between response time and memory, display and target conditions, separate linear trend analyses, in which response time was expressed as a function of display load, were performed for each group, and separately for target present and target absent data at each memory load condition. In every case the linear trends accounted for not less than 97.6% of the display load variance, and all linear trends were significant beyond the .01 confidence level. Details are given in Table 13. Thus, for each group, in every combination of memory load and target condition, response time increased linearly with display load.

For purpose of comparison with the fixed set character recognition experiments of Sternberg (1966), an examination



Graph 4. Response time as a function of memory load and target condition in one letter displays.

was made of response time, viewing it as a function of memory load (memory set size) where only one letter was displayed. The group mean response times for the single letter displays are presented in Graph 4, and Table 14 gives a summary of the results of a groups x memory load x target condition analysis of variance. The strongly significant memory load main effect indicates that response times increased with memory load as Sternberg (1966) and others have found. In further agreement with other studies, the lack of a significant memory x target (MT) interaction indicates that the rate of increase in response time with memory load was similar for both positive and negative probes, i.e. for target present and target absent, while the significant target condition main effects shows that negative response times were longer.

The significant groups main effect indicates that group mean response times differed. Comparison between paranoids and normals ($F = 14.94$; 1, 37 *df*; $p < .01$), nonparanoids and normals ($F = 31.55$; 1, 37 *df*; $p < .01$) and paranoids and nonparanoids ($F = 2.30$; 1, 37 *df*; $p < .10$) indicates that patient response times did not differ but that both schizophrenic groups produced longer response times than normals. The lack of a significant interaction involving the groups factor suggests that the rate of increase in response time with memory load in a single letter display is similar for patients and normals. Thus, although schizophrenics were slower, their response times were not affected to a greater or a lesser extent than normals by increasing memory load or changing target conditions.

Table 14. ANOVA Summary Table: Correct response times in the single letter display condition.

Source	SS	df	MS	F
Between subjects	9.85	39		
Groups (G)	3.22	2	1.612	9.01 **
Ss within	6.62	37	0.179	
Within subjects	11.33	200		
Memory load (M)	4.53	2	2.266	56.95 **
GM	0.27	4	0.069	1.75
M x Ss within	2.94	74	0.039	
Target condition (T)	0.36	1	0.361	13.10 **
GT	0.02	2	0.010	0.37
T x Ss within	1.02	37	0.027	
MT	0.01	2	0.007	0.26
GMT	0.12	4	0.030	1.10
MT x Ss within	2.03	74	0.027	
Total:	21.18	239		

** $p < .01$

Groups	Measures derived from regression analyses			
	slope	constant	% variance	*F*
Paranoid				
Target present	0.034	0.824	97.4	52.0
Target absent	0.025	0.918	95.8	11.5
Nonparanoid				
Target present	0.020	0.930	98.6	22.1
Target absent	0.029	1.126	95.9	8.9
Normal				
Target present	0.018	0.691	99.9	99.9
Target absent	0.016	0.765	99.5	41.7

Note: For paranoid and nonparanoid *F* ratios use 1, 19 *df*; for normals use 1, 39

Table 15. Results of linear trend analyses expressing response time as a function of memory load in the single letter display condition.

Individual group trend analyses, in which response time was expressed as a linear function of memory load, were performed separately on the target present and target absent data. Results of these analyses are given in Table 15. All linear trends were significant beyond the .01 level, and all accounted for at least 95.8% of memory load variance. Thus, for each group, in both target conditions, response time increased linearly with memory load when only a single letter was displayed.

CHAPTER FOUR

DISCUSSION

Results of the main analysis essentially confirm the findings of Nickerson (1966) and Briggs and Blaha (1969) and indicate that response time increased linearly with display load, and that this rate of increase was greater with increasing memory load. The rate of increase in response time was greater for target absent than for target present, and this difference between target conditions increased with memory load. Error rates were also affected by the memory and display load manipulations.

These findings are equally true of both schizophrenic groups and the normal group in that groups did not differ on any measure of the frequency of error, the rate of increase in error, or in the rate of increase in response time with memory and display load. This suggests that schizophrenics process information at much the same rate as normals and employ similar processing operations and strategies to normals. The one exception occurred in the memory conditions where only a single letter was displayed, in which the response times of both schizophrenic groups were significantly slower by a constant amount across all memory loads. As in Knight (1975) no differences were found in any of the analyses between paranoid and nonparanoid groups, and in future discussion these two patient groups will be referred to as one composite group, i.e. the schizophrenic group.

In separate analyses of visual and memory search two sets of models have recently been given some attention: "self-terminating" vs. "exhaustive" search and "serial" vs. "parallel" processing in the course of the search. Results from the separate analysis of the memory conditions for single letter displays indicate that the slopes for the "No" responses, which were necessarily the product of an exhaustive search, were similar to those of the "Yes" responses. These support previous studies, e.g. Briggs and Blaha (1969), Sternberg (1966), Wingfield and Branca (1970), Wingfield and Bolt, (1970), suggesting that in high speed memory search for the presence of a single probe, the memory ensemble continues to be scanned even after the target item has been encountered, i.e. the search is exhaustive for both "Yes" and "No" responses.

The position with respect to search for multiple targets is less clear. Sternberg (1967) claims that search of the memory items is exhaustive while search of the display is self-terminating, and that the whole process occurs in a serial fashion, while Neisser, Novick and Lazar (1963) argue for a parallel system of processing. However, it is doubtful whether models developed for tasks requiring scanning long lists of items are directly applicable to the processing of information in briefly presented displays, and, furthermore, several investigators, e.g. Atkinson, Holmgren and Juola (1969), Murdock, (1971), Townsend (1971, 1973) have shown that both serial and parallel systems may predict the same results.

While the findings of this experiment do not provide a basis for differentiating between the various models in a multi-target situation, some attention can be given to possible uses of strategy. This can be achieved by considering response times in relation to error rates. Firstly, it is necessary to note that miss response times in the high error conditions of $\underline{m} = 3$ and $\underline{m} = 6$, $\underline{d} = 15$ were always significantly greater than correspondingly correct target present response times and were never significantly different from correct target absent response times. This suggests that misses represented a considered decision reached after prolonged search and did not constitute merely rapid rejections of the possibility of a target being present. If we assume that, in the target absent $\underline{m} = 1$ condition, subjects processed all elements, and that the time taken to compare each displayed item with the memory item is equal to the slope, then, in the $\underline{m} = 6$ condition there are six such comparisons for each displayed element, and we would expect the $\underline{m} = 6$ slope to be six times that of the $\underline{m} = 1$ slope. An examination of the target absent $\underline{m} = 6$ slopes (see Graph 3) indicates that, assuming the same unit comparison times, the rate of increase in response times have increased by approximately half that which would be expected from the rate of increase in $\underline{m} = 1$, and that this is true for all groups. From these lower-than-expected rates of increase in response times and from the error data it appears that, as the task demands increased all subjects tended to trade speed for accuracy. A similar kind of proposition has been put forward by Nickerson (1966) who claimed that the high percentage of false negative responses (misses) in his study suggests that the search may terminate with a negative response after a certain amount of time has elapsed rather than terminating with the processing of the critical item in all cases.

The finding that schizophrenic response times and error rates were affected in no way differently to normals by manipulating memory and display loads and target conditions and its implication that similar processing operations and strategies are employed by both groups, has relevance for theories of cognitive deficit.

McGhie (1970) has hypothesized that schizophrenics experience difficulty in screening out irrelevant and distracting information. From his theory we would expect that schizophrenics would have difficulty performing in a visual search task because of the interfering effects of the so called irrelevant non-target letters. As a result of over-loading of perceptual mechanisms and a consequent failure to select out and respond to the relevant target letters, misses should be greatest in this group. We would further expect the false alarm rate to be higher for schizophrenics because in the $\underline{m} = 3$ and $\underline{m} = 6$ conditions, previous target letters appear as nontargets. However, the error data do not support these interpretations in any way. While patients tended to make more of both types of errors, this tendency did not reach significance in any memory load condition, and further, groups did not differ in the rate of increase in errors with either memory or display loads.

In terms of Yates' slow processing theory, searching through a visual display for a predefined target, i.e. at a stimulus processing level, schizophrenic response times should increase more rapidly than normals as the number of elements in the display increases. Using a variety of visual search tasks, several investigators, e.g. Knight (1975), Royer and Friedman (1973), Russell and Page (1976), have found that when memory load and response selection demands are minimal, the ability to perform the more purely stimulus processing operations of separating target from nontarget elements in a display is similar for both schizophrenics and normals.

This experiment extended the tasks of the investigators cited above by manipulating memory load as well as display load. In a multitarget situation where subjects are required to search for a number of memorized elements in a visual display, response times will include time taken to complete memory comparisons as well as that involved in the recognition of the items in the display. If we were to extend Yates' theory to apply to a situation requiring memory comparisons, then the time taken to compare an item in a display with an item in memory should be longer in schizophrenics than in normals. Consequently, schizophrenic response times should increase differentially as the number of possible pairs of comparisons increase, i.e. we would expect that the lines relating response time to increasing memory load to be nonparallel in schizophrenics and normals. However, no group interaction involving the memory factor was significant. It appears then, that neither increasing the number of letters to be scanned in a visual display nor increasing the number of targets to be searched for, differentially increases schizophrenic response times as opposed to normals.

Response times in both groups were equally affected by increasing memory and display loads.

The finding in other studies, e.g. Korboot and Yates (1973), Slade (1971), Yates and Korboot (1970) of a differential rate of increase in schizophrenic response times with increasing stimulus complexity may be the result of using a different type of task, and/or confusing stimulus and response uncertainty (as defined by Smith, 1968). Marshall (1973) in an experiment which improved on Slade's (1971) technique, compared schizophrenics with neurotic and prisoner controls. He found that schizophrenic response times were disproportionately lengthened seperately by both stimulus and response uncertainty, and he argued that the processing demands of stimulus uncertainty were not as great a source of difficulty for schizophrenics as those of response selection. Earlier evidence from reaction time studies by Venables (1965) support this conclusion. He found that when stimulus complexity was held constant, schizophrenic reaction times were more greatly slowed by increasing response complexity than were normals.

Conclusions and Directions for Future Research

One of the major problems in the research literature on schizophrenic cognitive deficit has been the lack of an overall theoretical orientation, and, up until recently, schizophrenic function was studied separately from mainstream cognitive psychology. While Yates' and McGhie's theories are valuable to the extent that they attempt to relate relatively modern ideas on cognitive functioning to schizophrenic deficit, they have lost much of their apparent validity because of their basis in the early Broadbent (1958) model of attentional processing. Acknowledgement of the limitations inherent in Broadbent's model has led to the undermining of the "defective filter" theory (Marshall, 1973) originally advanced by McGhie and his colleagues.

It appears that under certain experimental conditions schizophrenics may experience difficulty at both the stimulus and response ends of the processing system. Marshall (1973) argues that resorting to models which postulate a deficit at a specific stage of processing necessarily restricts our view. "It is clear that schizophrenics information processing capacities are defective compared with those of other subjects, and that this relative deficit is not isolated to any one aspect of processing." (p.420). The same author, as well as Checkosky (personal communication to Knight, 1973) suggests that models of choice reaction time, which permit the description of capacities of most if not all levels in the system, are more suited to an understanding of schizophrenics' difficulties.

Knight (1973) has argued that the nonspecificity of the schizophrenic disorder lends support to a capacity theory such as that proposed by Kahneman (1973) in that such a formulation does not postulate a priori any particular aspect of processing being deficient. However, a major research problem exists in how task "demands" are to be quantified.

The overall result of the present study has been to show that increasing complexity of both stimulus and memory loads in a visual search task involving discrete trials has much the same effect on response times and error rates of schizophrenics as it does on those of nonpsychiatric controls. Work carried out by Marshall (1973) and others suggests that the most fruitful area to concentrate on might involve response selection. However, in order to differentially expose processing at various levels, future studies will require a series of experimental tasks.

Perhaps one of the major shortcomings in this study was in not recording patients' daily drug dosages for later correlational analyses. It is further noted that, had it not been for the time contraints of this thesis, it would also have been desirable to perform correlational studies between other subject variables and subjects' performance.

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